Proposed Melt Shop Evaluation Protocol

Sterling Steel Company, LLC – Sterling, Illinois
November 15, 2016

Prepared for:
Sterling Steel Company, LLC
101 Avenue K
Sterling, Illinois 61081
Attn: Mr. Evan Buskohl

Submitted To:
Air Enforcement and Compliance Assurance Branch
US Environmental Protection Agency
Region 5
77 W. Jackson Boulevard
Chicago, Illinois 60604
Attn: Compliance Tracer, AE-17J

Prepared by:

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& Associates, Inc.

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1 Copy	Seyfarth Shaw 131 S Dearborn Street Suite 2400 Chicago, Illinois 60603 Attn: Ms. Jeryl Olson

1.0 INTRODUCTION

Gas Cleaning Technologies, LLC (GCT) and RK & Associates, Inc. (RKA) has been retained by Sterling Steel Company, LLC (SSC) to design a Meltshop evaluation protocol and will be implemented by GCT after the subject protocol is approved by the USEPA.

This protocol is designed to estimate the ventilation capture efficiency for SSC's only furnace, EAF furnace number 8, over the entire process operating cycle (i.e., charging, melting and refining, and tapping operations).

The proposed CFD modeling Ventilation study can only account for the immediate capture efficiency of the canopy hood during specific operating conditions and does not account for delayed capture by canopy over the entire operating cycle. During the delayed capture of emissions over the entire operating cycle, there is release of particulate matter within the Meltshop building which will not be accounted for by the CFD model. The release into, and deposition rate of particulate within the Meltshop building, is dependent on the particle size, along with other factors. CFD modeling addressed here will not quantify this collection of particulate matter within the Meltshop building; rather USEPA established factors (see section 3.5 of this protocol for further details) will be utilized to evaluate the Meltshop building capture during this study.

1.1 Facility Location

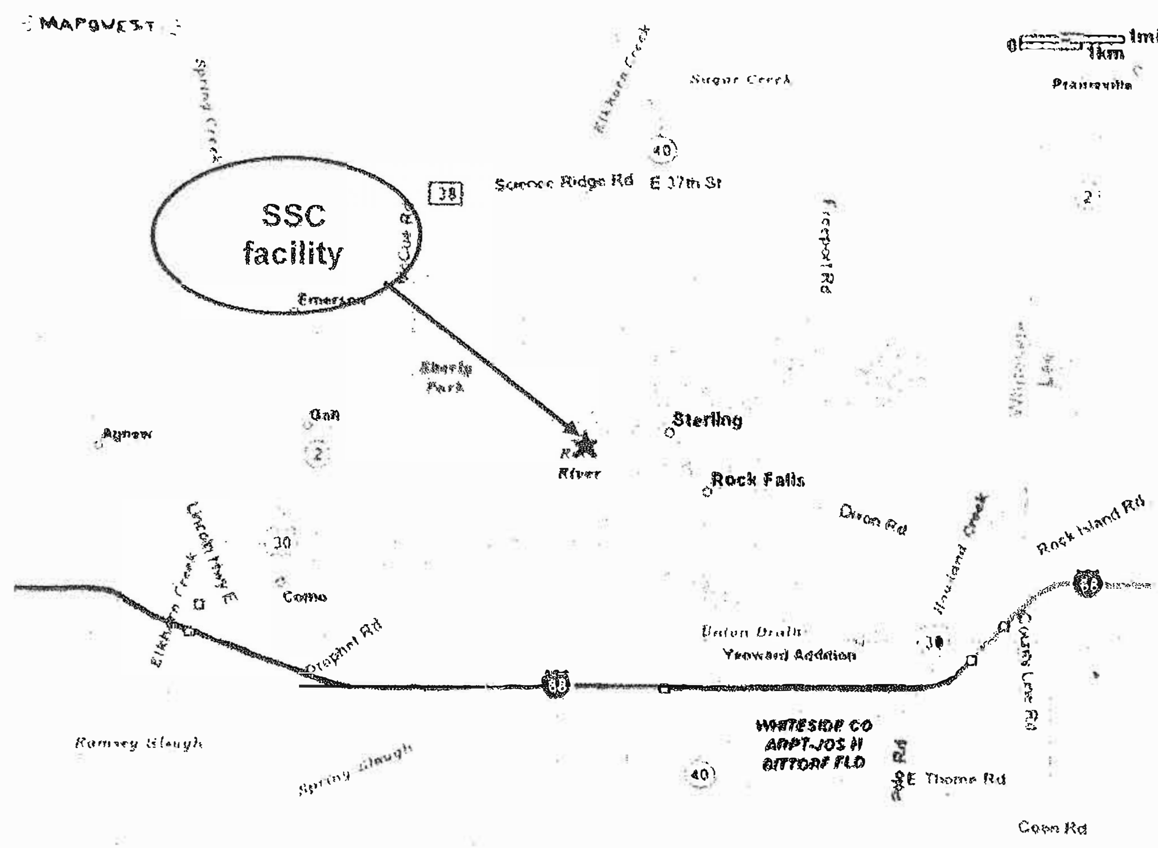
The SSC facility is located on the southern border of the City of Sterling, Illinois and is directly north of the City of Rock Falls. The facility borders the Rock River, which runs along the southern-most border of the plant. Specifically, the SSC facility is located along Wallace Street in Sterling (See Figure 1).

1.2 Test Participants

SSC's technical representative for this test protocol is Mr. Evan Buskohl, Environmental Manager. Questions regarding the physical operations and operating condition at the facility may be directed to Mr. Buskohl at (815) 622-7251.

SSC has retained GCT to conduct Meltshop evaluation ventilation study.

Questions regarding this protocol may be directed to SSC legal counsel Ms. Jeryl Olson at (312) 460-5802. This testing program will be coordinated and supervised by RKA.



RK & Associates Inc. 25631 ROUTE 59, SUITE B WARRENVILLE, IL 60555 630-393-9000/630-790-2966	COMMENTS: Meltshop Evaluation Protocol		SITE LOCATION MAP Sterling steel Company, LLC Sterling, Illinois		FIGURE 1
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2.0 SOURCE DESCRIPTION AND OPERATING CHARACTERISTICS

SSC is a mini mill and rolling mill facility which manufactures semi-finished billets and finished rod. The manufacturing process fundamentally involves the melting of recycled scrap metal in an EAF into semi-finished steel, and subsequent rolling of these products into finished products.

2.1 Electric Arc Furnace (EAF) System Operation

Process description: SSC operates one Electric Arc Furnace, EAF No. 8. The EAF melts recycled scrap metal and other raw materials into molten steel with electric arcs from carbon electrodes.

EAF raw materials include recycled scrap metal that is charged to the furnace from a scrap bucket. Limestone and carbon are introduced into the refractory-lined EAF to remove impurities from the charged scrap metal. The injection lances add carbon to the furnace in order to create a good slag layer, accelerate the liquefying process of scrap metal, and remove adhered pieces of metal attached to the refractory-lined furnace and to improve metal grade.

The raw material from the aforementioned process will yield molten steel. Molten steel is transferred to the caster by ladles where the steel is then poured into natural gas preheated tundishes, where the liquid is molded into billet semi-finished metal pieces.

The by-products from the recycled scrap melting process yield slag and particulate matter. Slag is a product formed from the carbon and limestone in conjunction with the recycled scrap metal. The slag is removed from the furnace while the furnace is tilted. The slag pours into a subbasement and is removed by an end loader and transported to a recycling area for further processing to yield saleable by-products.

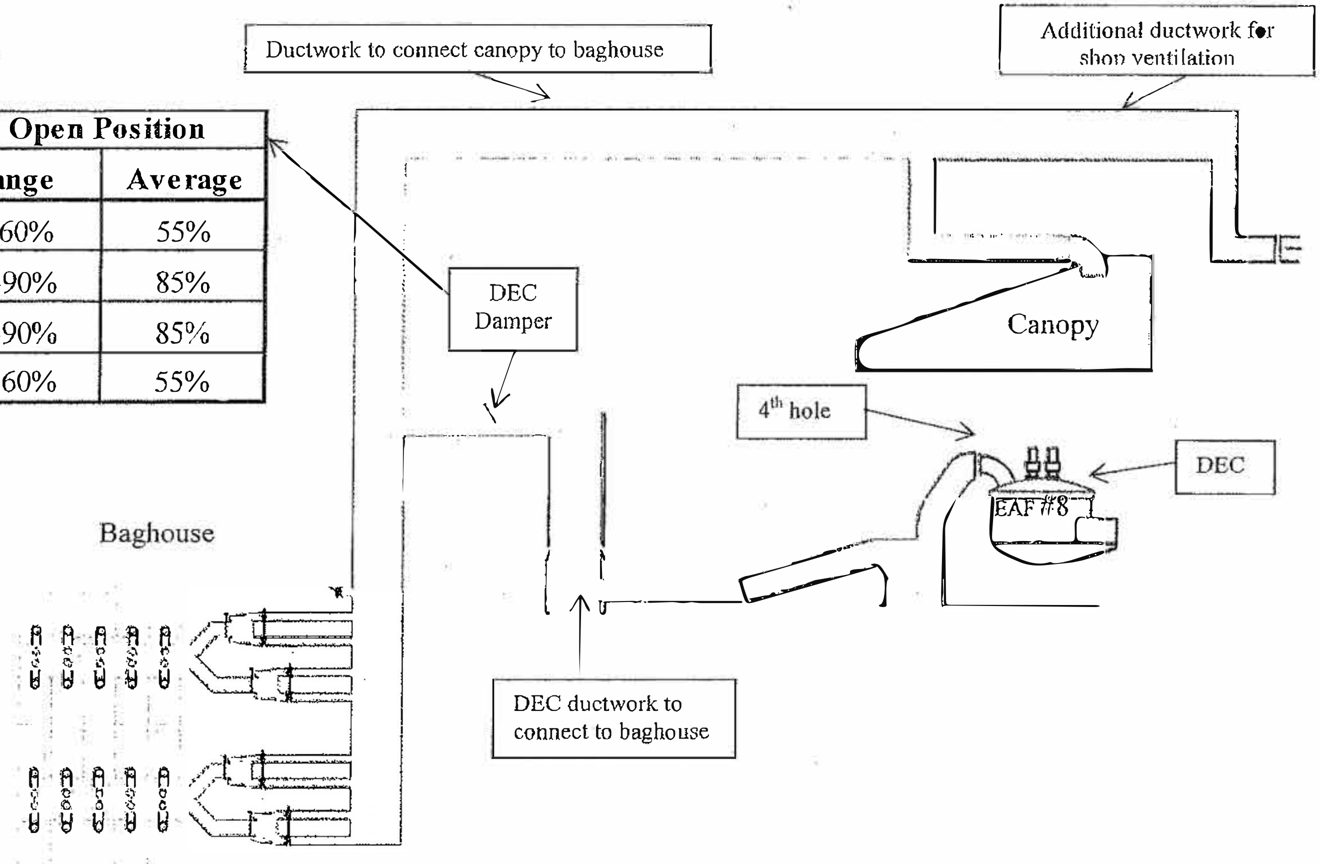
The particulate matter associated with EAF operations are generated during and are characterized by four processing categories: charging, melting, refining, and tapping. The SSC EAF emissions capture system removes particulate matter from the melting and refining stages via a "4th-hole" direct-shell evacuation control (DEC) system. Secondary capture systems are employed through a hood capture system, a canopy hood located above the furnace captures particulate matter generated during the charging and tapping process, as well as any material generated from the EAF during melting and refining that are uncollected through DEC system. The combined EAF DEC system and canopy hood ventilation direct particulate to a baghouse for collection before venting of gases and uncollected particulate matter to the atmosphere. Figure 2 provides a layout drawing of the captured PM streams from both the 4th hole DEC and hood capture system, to the baghouse.

2.2 Electric Arc Furnace (EAF) System Operation details

Identification of highest and range of production rates for EAF: The EAF production range for SSC is normally from 150 ton molten steel/hr. to 210 ton molten steel/hr. The SSC facility is permitted for 280 ton/hr. and 1,630,000 tons/yr. During the subject evaluation, the EAF production level will be maintained at 180 ton of molten steel/ hr. (the same rate as used during the December 2015 stack test).

Description of how air pollution control and process equipment will be monitored: SSC maintains detailed records of individual heats along with baghouse operating details such as pressure drop and amp readings. These data are recorded in "heat Sheets". The proposed location for air flow monitoring of the canopy hood is presented in Figure 3.

DEC Damper Open Position		
Operation	**Range**	**Average**
Charging	50-60%	55%
Melting	80-90%	85%
Refining	70-90%	85%
Tapping	50-60%	55%



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Meltshop Evacuation Process Schematic
Sterling steel Company, LLC
Sterling, Illinois

FIGURE 2

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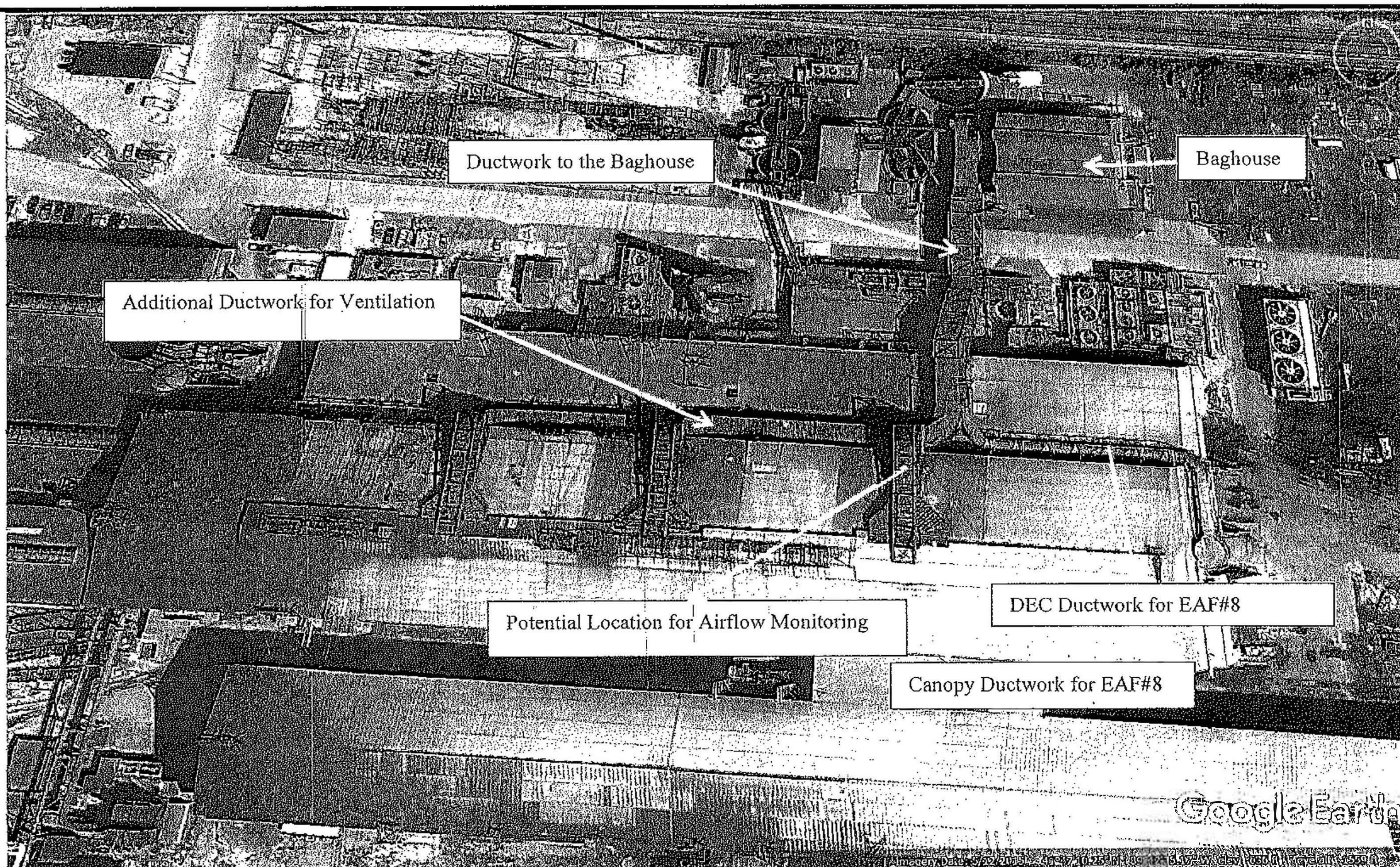

RK & Associates, Inc. 2S631 Route 59, Suite B Warrenville, IL 60555 630-393-9000/630-393-2966	COMMENTS: Meltshop Evaluation Protocol		Potential Airflow Monitor Location Sterling steel Company, LLC Sterling, Illinois			FIGURE 3
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3.0 METHODS FOR ANALYZING CURRENT CAPTURE AND PROCEDURE

The following sections describe the methods to be used to determine particulate matter capture efficiency for the EAF during charging, melting, refining, and tapping operations.

3.1 Test Parameters and Measurements.

The first step in the exercise to determine capture efficiency is to evaluate the EAF melt shop's emissions control systems. This requires a study of the existing process operations for the EAF and other major fume/particulate matter generating sources inside the Meltshop building as well as an assessment of the overall Meltshop air pollution control system.

The Meltshop air pollution control system review will:

- Establish the existing operating conditions for the system
- Calculate the capture efficiency of the DEC system
- Provide necessary boundary conditions (e.g., ambient wind condition, exhaust flow rates, and energy release from EAF operations, etc.)

<u>Ductwork Flow Rate and Temperature</u>

Ductwork air velocity, pressure, and static pressure measurements will be collected using a "S" or "J" type pitot tube with digital manometer. Gas temperature will be measured using a K-type thermocouple with digital thermometer. GCT's flow rate and temperature measurement methodology follows EPA Methods 1, 1a, 2, 2a, 2c and 2d, as appropriate for duct size, location and type of pitot tube used.

GCT will conduct flow and temperature measurements at 1 to 5 minute intervals, depending on the length of the operating cycle and the expected variation in the gas conditions. When a large gas variation is expected or if the specific operating cycle is less than 30 minutes, measurements will be done every 1-2 minutes. If there is negligible gas flow variation or if the cycle time is greater than 1 hour, then measurements will be taken every 5 minutes. GCT will collect these measurements for multiple operating cycles to obtain a more representative average of the data.

Ductwork measurements in the EAF Meltshop will be collected at the following locations:

- DEC ductwork at exit of water-cooled duct or spray chamber
    - Velocity pressure, static pressure, and temperature
    - Measurements collected at 2 minute intervals for a minimum of 2 heats
- Canopy Hood duct before DEC tie-in
    - Velocity pressure, static pressure, and temperature
    - Measurements collected at 5 minute intervals for EAF melting, 1 minute intervals at charging, 2 minute intervals at tapping
- Baghouse inlet
    - Velocity pressure, static pressure, and temperature are measured
    - Measurements collected at 5 minute intervals for a minimum of 1 complete heat
- Baghouse reverse air fans
    - Velocity pressure, static pressure, and temperature
    - Spot measurements are taken to confirm operating conditions

The ductwork measurements will allow GCT to establish the ventilation and gas conditions for each specific phase of the process operation and to calibrate the process mass and energy balance calculations.

Gas Analysis

GCT will conduct gas analysis to measure CO, CO_2, NO_x, and O_2 at the exit of the DEC water-cooled ductwork or spray chamber. GCT will utilize EPA Methods 3a, 6c, 7e and others for testing and analysis of gaseous components in flue gas on a wet gas basis using a Testo 350 portable gas analyzer.

The gas analysis will be used to augment the flow rate and temperature measurements in calibration of the mass and energy balances.

Building Ventilation Survey

Building ventilation surveys will be conducted using a propeller vane anemometer and digital thermometer. Air flow rate into and out of the meltshop will be measured at the various openings identified in Figure 4. Multiple velocity recordings will be taken at each opening, depending on the size of the opening, in order to obtain a representative average velocity for that specific opening. At the start and conclusion of a survey, GCT will evaluate the general ground level wind conditions by taking velocity and temperature measurements in a clearing away from the meltshop or other buildings.

The building ventilation survey will be used to develop boundary conditions (e.g., ambient wind condition, exhaust flow rates, and energy release from EAF operations, etc.) and calibration of the process modeling.

Plume Videography

GCT will conduct videography of particulate generated during melting, refining, charging, tapping, and in between these operations. This will involve the use of a digital video camera positioned in the meltshop at a distance from the EAF where the camera can capture the rise of the particulate plume from the EAF to the canopy hood.

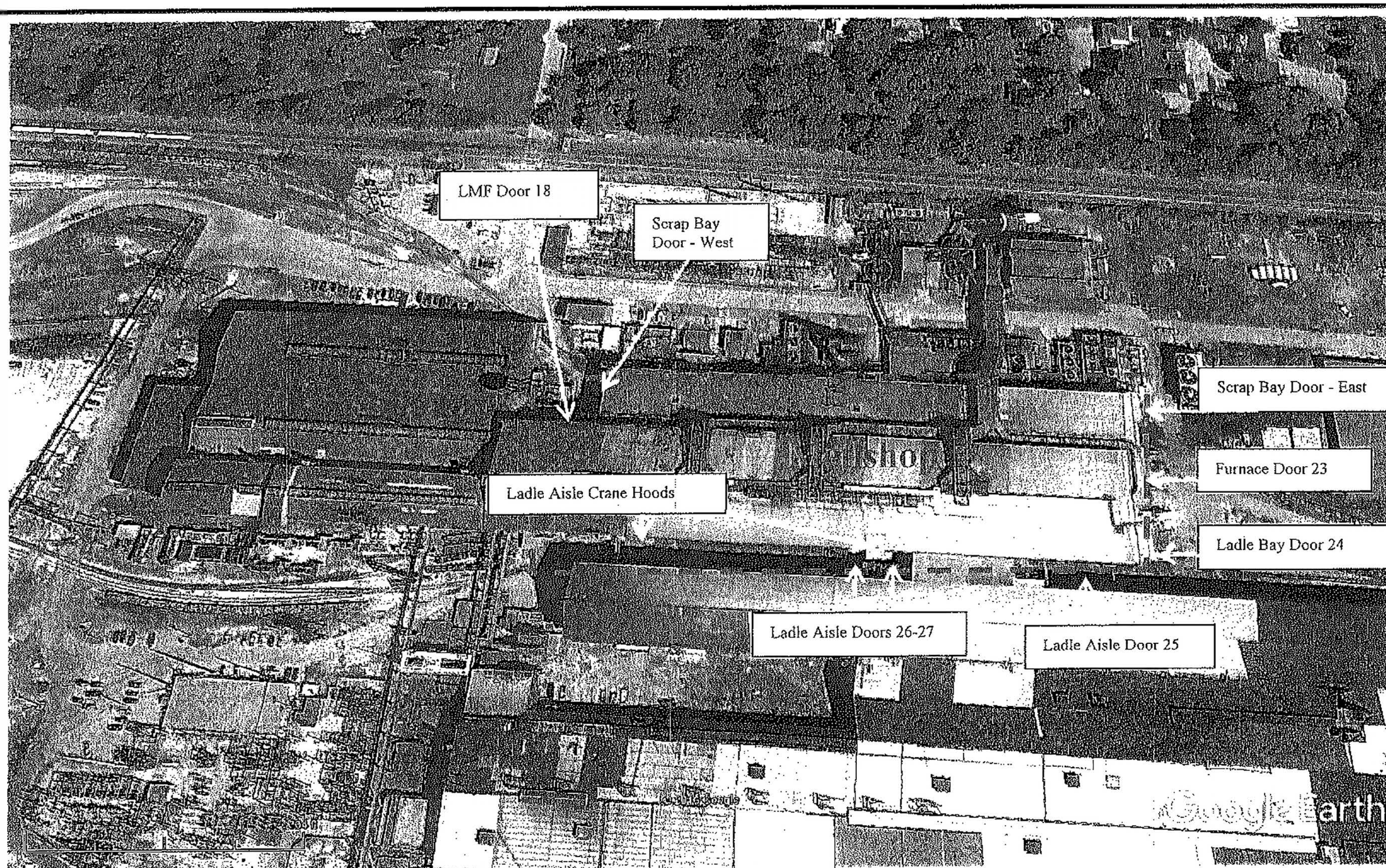
The videography will be used to establish the plume characteristics for each EAF operating mode. The results will be used to develop boundary conditions and calibration of the process modeling.

EAF Operations

GCT will record major operating conditions, including power input, burner fuel, oxygen injection, carbon injection, and other parameters that impact the energy input into the EAF or fume generation. GCT will collect the operating "heat sheets" for the duration of the testing period to further augment the direct data collection. GCT will utilize this information to develop a process mass and energy balance model of the EAF.

Baghouse and ID Fan Operation

GCT will collect the design and operating parameters for the baghouse and ID fan system including pressure drop across the baghouse, gas flow rate and temperature, fan amperage and rpm, and damper logic.



RK & Associates, Inc. 28631 ROUTE 59, SUITE B WARRENVILLE, IL 60555 / 630-393-9000/630-790-2966	COMMENTS: Meltshop Evaluation Protocol		**Meltshop Building Openings** Sterling steel Company, LLC Sterling, Illinois	FIGURE 4
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3.2 Testing Schedule

The proposed testing schedule will be as follows:

Day 1

- DEC and canopy hood ductwork for 2-3 heats, approximately 4-5 hours
- Ventilation survey, in afternoon (see building ventilation survey in section 3.1 for details) – 2 hours (initial survey takes longer as openings are identified and measured)

Day 2

- Ventilation survey in morning – 1 hour
- Baghouse inlet measurements for 1-2 heats, approximately 2-3 hours
- Baghouse reverse air fan measurements, approximately 30 minutes
- Plume videography – 2-3 hours
- Process observations – 2-3 hours
- Ventilation survey in afternoon – 1 hour

Day 3

- Ventilation survey in morning – 1 hour
- Additional ductwork measurements, as necessary
- Process observations – 1-2 hours
- Ventilation survey in afternoon – 1 hour

3.3 Data Analysis

The analysis of the site data collection and measurements will include:

- Development of an EAF mass and energy balance

  EAF operating data will be analyzed using an Excel based mathematical model of the EAF operation to define the process off-gas conditions during melting and refining. Sample results of EAF model are shown in Figure 5 and Figure 6.

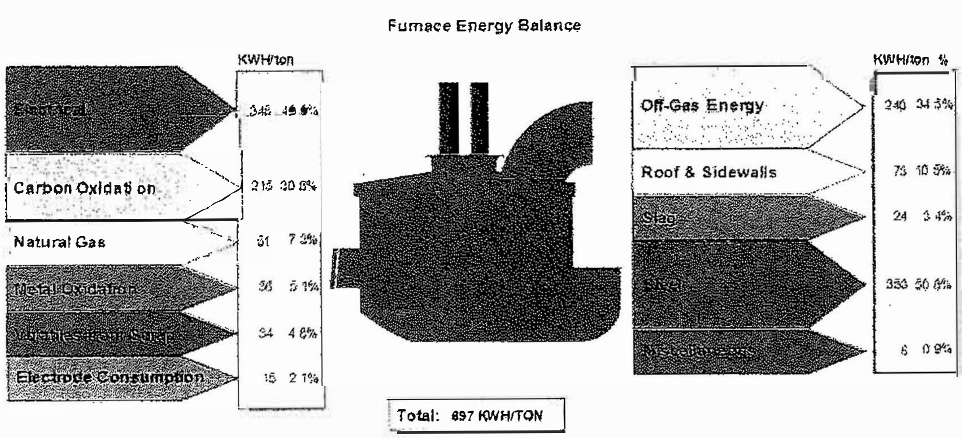

Figure 5: Sample EAF Mass and Energy Balance Results

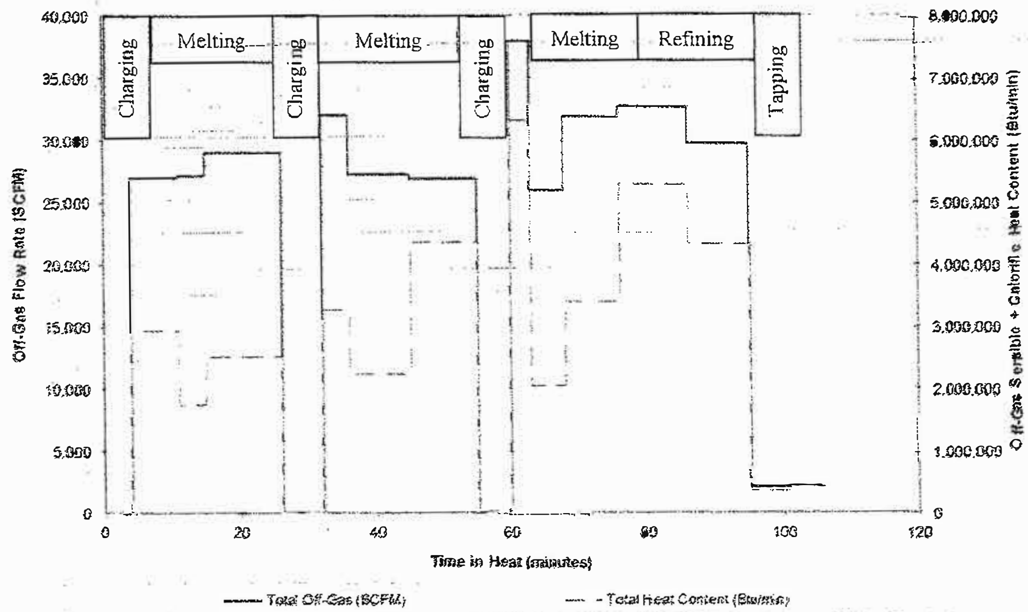

Figure 6: Sample EAF Process Off-Gas Calculation Results

- Development of an off-gas system mass and energy balance

  The ductwork measurements will be analyzed to match up gas flow rates with EAF operating conditions. Sample results are shown in Figures 7 and 8.

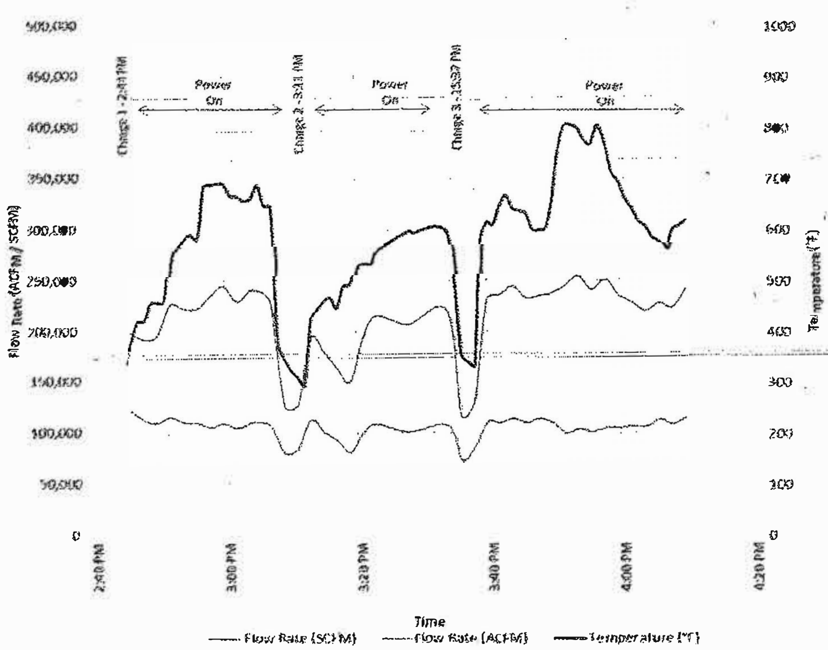

Figure 7: Sample DEC System Ductwork Measurements

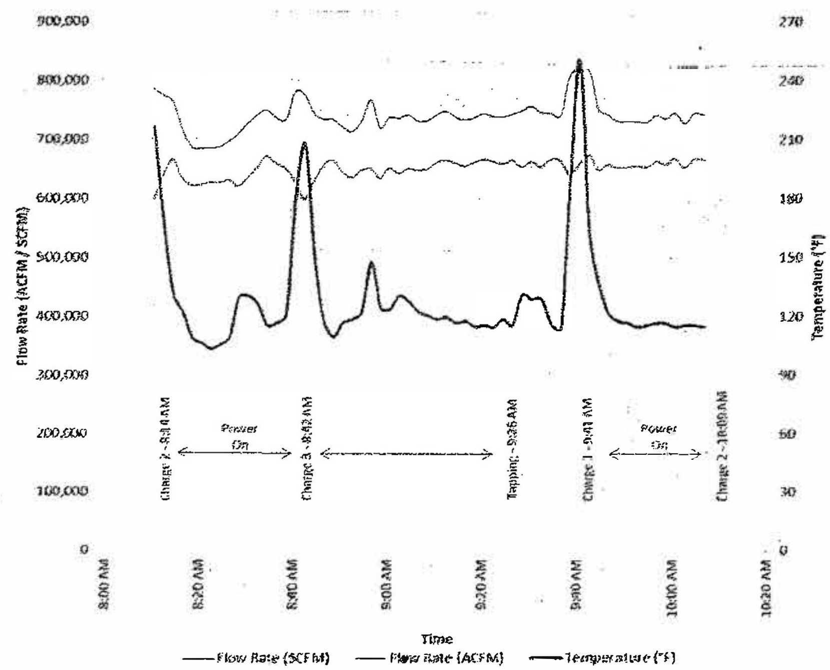

Figure 8: Sample Canopy Hood Ductwork Measurements

The off-gas characteristics derived from Figure 6 will be input into an Excel based off-gas ductwork system model. The model will then be calibrated against ductwork measurements and gas analysis. When calibrated, the model will identify the melting and refining off-gas capture efficiency of the DEC system in order to match up with the measurements.

- Development of plume characteristics

The videography will be analyzed for velocity, diameter and entrainment angle to establish the plume flow rate and extent as it reaches the canopy hood for various operations. For example, during charging, the video will be used to time the various configurations during charging (roof open, bucket over furnace, scrap charge, remove bucket, roof close), then to calculate the total fume and heat release during these steps. Sample results for plume characteristics are shown in Figure 9.

Augmented by traditional hood design calculations, this information will establish the volume requirements for the canopy. Also, if there are significant cross-drafts, this method will be used to estimate the amount of the plume that enters the canopy hood versus that drifting away from the hood.

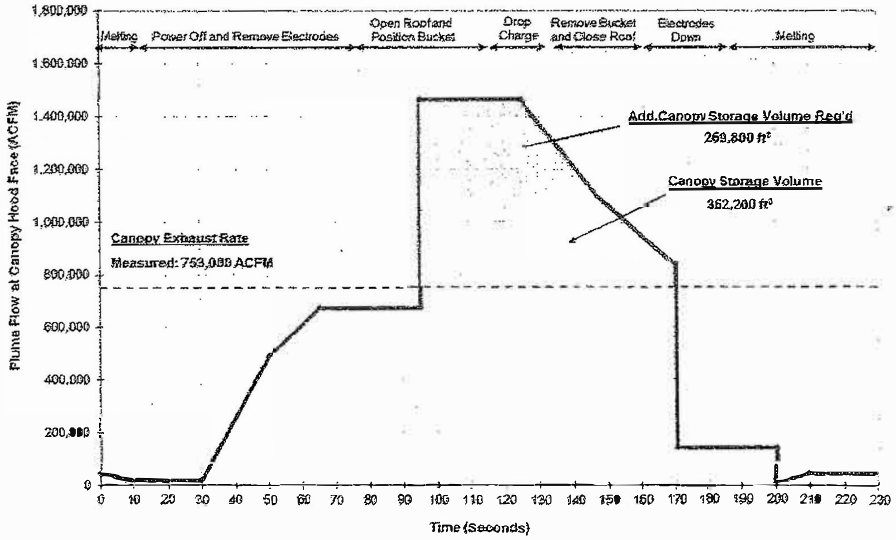

Figure 9 : Sample Charging Plume Profile

3.4 Computational Fluid Dynamic (CFD) Modeling

Computational Fluid Dynamic (CFD) modeling will be used to develop velocity, temperature and dust concentration profiles to assess the overall meltshop ventilation patterns and the fume control systems. It will be used to predict and evaluate:

- Performance of the ventilation system
- Airflow pattern and dust migration path

Model Development

A three-dimensional model of the area to be studied for heat transfer, fluid flow and mass transfer will be developed using CHAM's Phoenix proprietary software package.

The transport equations will be solved numerically using a control volume finite difference method. The domain of calculation will be chosen and thermal, momentum and mass transfer boundary conditions will be specified. Drawings and field observations will used to develop the geometrical configuration of the 3D model.

GCT will use a combination of videography, ductwork measurements, ventilation surveys, and heat/mass balance calculations to define boundary conditions for the CFD modeling.

EAF melting and refining boundary conditions will be derived from the calculated DEC system capture efficiency and plume videography. EAF charging and tapping boundary conditions will be derived from the plume videography, hood design calculations and canopy hood ductwork measurements.

Some secondary heat sources such as standing ladles, ladle clean-out area, etc., will be modeled based on the size of the heat source and thermal properties of the molten or scaled metal.

Model Calibration

The CFD model will be calibrated against the ventilation surveys. The air flow rates through openings and temperatures inside the meltshop will be compared with the model results.

The EAF plume characteristics from the videography will also be used for calibration. The plume rise, entrainment angle, and diameter will be compared with model predictions as another means to validate the CFD.

CFD Analysis

During the data analysis and assessment phase, GCT will conduct CFD modeling for the following scenarios:

Calibration/Validation – at ambient conditions during the testing and survey period

- Melting – typically 4-5 modeling runs are necessary to calibrate the model
- Charging – 2-3 modeling runs to calibrate the model, using the calibrated melting model as the basis

Melting

- At 90th percentile of wind speeds from prevailing direction(s) – 2-3 models
- Efficiency assessment at higher exhaust rates for worst case scenario – 3-4 models

Charging

- Efficiency assessment at present and higher exhaust rates for worst case scenario – 4-5 models

Tapping

- Efficiency assessment at present and higher exhaust rates for worst case scenario – 4-5 models

Meltshop Modifications

- 5-6 modeling scenarios for various meltshop openings or canopy hood modifications

Examples of the EAF charging model results are shown in Figure 10.

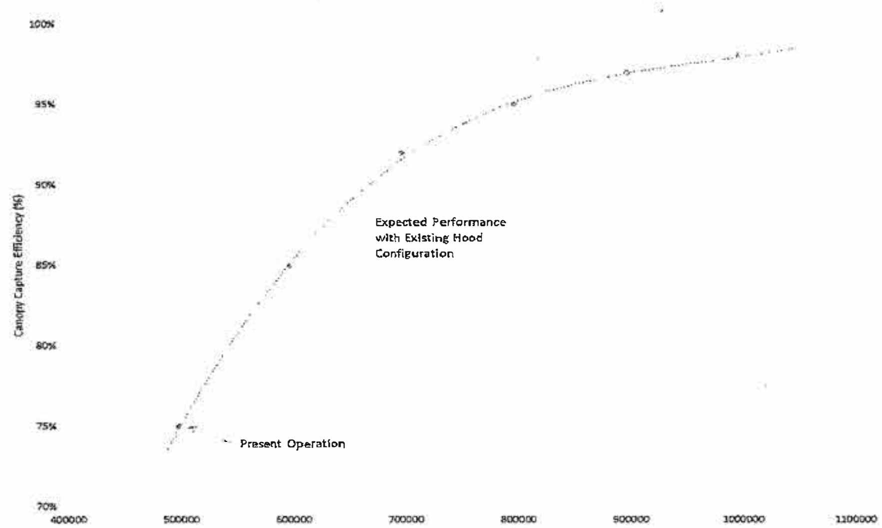

Figure 10: Sample Canopy Hood Capture Efficiency Curve

3.5 Limitation of Current Capture Determination Procedure

The steady-state CFD modeling will not be able to calculate or predict the collection of particulate matter inside the Meltshop that is the results cannot predict the amount of dust/fume that settles inside the meltshop during operations versus that which could escape from the Meltshop openings as fugitive emissions.

During melting, the canopy provides a percent capture of furnace emissions while the rest is assumed to drop out in the building. This is a valid assumption since the temperature and updraft velocity of the melting plume is very low, and any particulate that goes outside of hood exhaust extents will not have the momentum to carry it out of roofline eaves or other higher level openings. GCT's experience and visual observations show that only a negligible amount of this melting plume may be carried out of ground level openings, and only if there is sufficient building cross-drafts at that time. During charging and tapping, the plume has a higher temperature and updraft velocity. The plume that does not get captured by the canopy hood during charging and tapping generally stays inside the building at the roof level for an extended period of time. Although much of this plume includes larger particulates generated during charging/tapping which settle inside the Meltshop, there is the potential for the smaller particulates to remain near the roofline for some period.

<u>Meltshop building efficiency determination:</u>

The building capture efficiency (bc) will be assumed to be 80%. GCT is not aware of any specific study literature or method to determine the building capture efficiency. However, there is background document within the US EPA and CDC libraries that support the 80% building capture efficiency. It is reported that typical iron dust is in the range of 4 to 20 micron, and that iron foundry pouring operations result in dust with 60% of particulates over 50 micron. GCT expects that a significant portion of the charging particulate matter (which are larger and more severe than tapping particulate matter), to be over 100 microns. The terminal velocity of particles above 10 microns is 40 fpm (100 fpm for particles over 100 micron) meaning that the melt shop would have to maintain an overall updraft of greater than 40 fpm to keep particles entrained. Based on the melt shop geometry and baghouse design, the existing overall updraft velocity in the EAF aisle is less than 10 fpm, indicating a significant portion of the particulates would settle in the shop. This assumption is consistent with the relatively large volume of dust which is routinely removed by SSC from the interior of the Meltshop, 200-300 tons per year.

<u>Uncontrolled PM emission factors for EAF operations</u>

In addition, the following uncontrolled <u>emission factors</u> (from <u>AP42</u>, 1/95, table 12.5.1 - Also used in the Alton steel title V permit dated 5/13/2008) will be used to estimate particulate mass emission rates from EAF operations.

Melting and refining: Uncontrolled 38.0 lb/ton
Charging, tapping, and slagging: Uncontrolled emissions 1.4 lb/ton

3.6 Energy Calculation Methodology

As discussed in Section 3.3, the DEC system capture efficiency will be established using Excel based mass and energy balance models, not with CFD modeling. The Excel based models will provide an assessment of the amount of off-gas generated through various melting phases and the amount of off-gas captured by the DEC system. The off-gas not captured in the DEC system will be used in the CFD model to assess the ability of the canopy hood to collect the remaining gas. In this way, the melting and refining capture efficiency (DEC + Canopy) will be quantified.

3.7 Procedure to Estimate Individual and Overall Capture Efficiency of the EAF melt shop

Individual Capture Efficiency for Each of the EAF Operations

Considering the above, CFD modeling study will predict PM capture efficiency (CE) of the DEC and canopy during charging, melting/refining, and tapping using a steady state exhaust gas flowrate:

- CE during Charging- x% at the steady- state exhaust air flow rate using canopy only.
- CE during Melting/refining - y% at a steady state using the DEC and canopy)
- CE during Tapping - z% at a steady state using canopy only.

PM capture efficiency for the melt shop building will be estimated using procedure stated in section 3.5. A large amount of material (between 200 to 300-tpy) is collected from the melt shop floor, and other interior areas, indicating that a significant portion of uncaptured particulate matter settle out in the building.

Using the above-mentioned CFD modeling capture efficiency and estimated building capture efficiency, The following equation will be used to determine PM capture efficiency including building capture efficiency at each of the SSC's EAF operations:

$$\eta_c = x, y, or\ z + \left((1-x), (1-y), or\ (1-z) * bc\right)$$

Where:

η_c = Individual EAF PM Collection efficiency for a given operation, charging, melting/refining, and tapping.

x = is the study PM Capture efficiency (in %) during charging

y = is the study PM Capture efficiency (in %) during melting/refining

z = is the study PM Capture efficiency (in %) during tapping

bc = the building capture efficiency (in %) applied to PM emissions not captured by the Canopy and DEC

Overall Meltshop capture efficiency

The overall PM collection efficiency during an entire heat cycle is dependent on the amount of time for charging, and the amount of time for melting/refining, and tapping.

Assuming that charging and tapping represents 20% of operating time (this will be confirmed during the subject test) during a typical heat, the overall weighted average melt shop PM capture efficiency will be calculated using the following equation.

$$\eta_w = (\eta_c\ for\ charging) x\ 10\%) + (\eta_c for\ meling/refing\ x\ 80\%) + (\eta_c for\ tapping\ x\ 10\%)$$

Where:

η_w = Overall melt shop PM capture efficiency

4.0 MELTSHOP EVALUATION REPPORT

RKA will prepare a final report documenting the sampling and analysis methods, procedures, and results. All pertinent sampling and analytical information, unusual conditions experienced during the test procedure, etc., will be included in the test report. At a minimum, the final report will include the following sections:

- Summary of test results
- General information
- Description of test methods, including description of sampling points, sampling train, analysis equipment, and test schedule.
- Detailed description of test conditions including process information, and control equipment information.

Further details about the report are provided as follows:

4.1 Current capture efficiency at the canopy and the DEC, during charging, melting, refining, and tapping:

a. the design capacity (i.e., flow rate) of the exhaust gas capture and collection system, including the DEC, the canopy hoods, and the baghouse/fans;

b. the calculated fume generation flow rate during charging, melting, refining, and tapping;

c. the actual flow rates that are associated with the exhaust gases during EAF operations as measured at the fourth hole and canopy hood;

d. capture efficiency during charging, melting, refining and tapping, and overall capture efficiency;

The study will provide the following:

Instantaneous capture efficiencies, using CFD modelling, during charging, melting/refining, and tapping. Capture efficiencies for each EAF operation including building control efficiency will also be estimated. Meltshop building control efficiency will be estimated using method described in section 3.5 of this protocol. Overall Meltshop capture efficiencies will be estimated after accounting for the operating time of each of the EAF operation (see section 3.7 of the protocol).

e. a plot of predicted capture efficiency vs airflow at the canopy hood ; and

f. Potential locations for airflow monitor at the canopy hood or associated duct work for either permanent installation or a location that can be regularly accessed.

4.2 Brief description of sampling and analytical methods.

A brief description of the actual sampling and analytical methods employed during the meltshop evaluation will be summarized. The reference sampling methods are described in Section 3.1.

4.3 Appendices: Copies of any and all raw field data, including the following:

a. Complete results, with example calculations (as appropriate);
b. Photos and videos;
c. Air flow measurements at fixed openings, wall louvers, and doors (as appropriate);
d. Air flow velocity, pressure, and temperature readings inside the shop, in the ducts, at the dust collector units, and at the hoods.
e. Heat sheets;
f. CFD modeling inputs and outputs;
g. Operating data (fan performance, baghouse operating data, etc);
h. Sampling port locations and dimensioned cross sections (as appropriate); and
i. Calibration procedures and results.

5.0 SCHEDULE

Once the protocol is approved by USEPA, GCT and RKA can complete the work within 60 days. A final report can be issued within 45 days thereafter